

Origins of Human Innovation and Creativity: Breaking Old Paradigms

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Where does human innovation and creativity come from? How did it arise? Did it need a set of triggers, and, if so, what were they? Can we discern patterns in the creative thought process just by examining the artefacts (mostly stone tools) preserved in archaeological sites, or should we be using other methods to reconstruct this fascinating aspect of human history? These questions, and others, were addressed by a group of archaeologists at a symposium sponsored by the British Academy in September 2009. The symposium was so interesting, and the participating speakers were so stimulated by the topic, that we decided to develop the theme into this edited volume of papers. The chapters in this book are wide ranging, and approach these questions from many different angles, focussing on a variety of human species, study regions and time intervals (Fig. 1.1). Their papers certainly challenge, if not break, some old paradigms.

One of the ways to look at the origins of creativity and innovation is to examine the physical evolution of the human brain. This has been facilitated in recent years through the development of rather sophisticated 3-dimensional modelling of the size and shape of human brains, ranging from modern humans back through most of the ancestral species. If a fossil skull is available for a species, then the brain lodged in that skull can be reconstructed with surprising precision, so that the size and shape of the various lobes of the brain can be measured accurately. It is clear that brain size has increased throughout the course of human evolution. As is well known, humans have an exceptionally large brain relative to their body size. For example, the brain weight of humans is 250% greater than that of chimpanzees, while the human body is only 20% heavier. Our ancestors living 2–2.5 million years ago had an average brain weight of 400–450 g, while our more immediate ancestors living 200,000–400,000 years ago had an average brain weight of 1350–1450 g. This threefold increase in size represents one of the most rapid morphological changes in evolution, even

though its genetic basis remains elusive (Zhang, 2003). It is generally believed that the evolution of larger brain size set the stage for the emergence of human language and other high-order cognitive functions, and that it was driven by adaptive selection (Decan, 1992), but, as Schoenemann (2006) noted, it is clear that the human brain is not simply a larger version of the brains of our primate relatives. Rather, there are disproportionate increases in some parts of the brain, such as the frontal lobe. The changing shape of the human brain should provide clues about the behavioural evolution of our species. The evolutionary costs of growing and maintaining these masses of neural tissue must have been offset by some sort of adaptive (reproductive) advantages to successive populations of ancestral humans. Surely one of the main advantages must have been an increased capacity for innovative and creative thought.

It turns out that the psychologists and physical anthropologists who study such things do not all agree on which parts of the brain are the source of creative thought. Some of those who study the functioning of the modern human brain assert that the centre of creativity is found in the frontal lobes of our species. If so, then the so-called “executive functions” of the frontal lobes may have facilitated the evolutionary ascendancy of humans (Coolidge and Wynn, 2001). The mental activity of the frontal lobes is considered by some to give rise to “all socially useful, personally enhancing, constructive and creative abilities” (Lezak, 1982).

Other authors have pointed to other parts of the brain as playing a central role in the evolution of human cognition and innovative thought processes. For instance, a study of changes in the shape and size of the various parts of the brain in the genus *Homo* reached the conclusion that the development of the parietal lobes in modern humans is the only nonallometric difference between *Homo sapiens* and nonmodern taxa, and that this morphological change may have represented a discrete cognitive shift (Bruner, 2004). According to this study, the parietal cortex may have

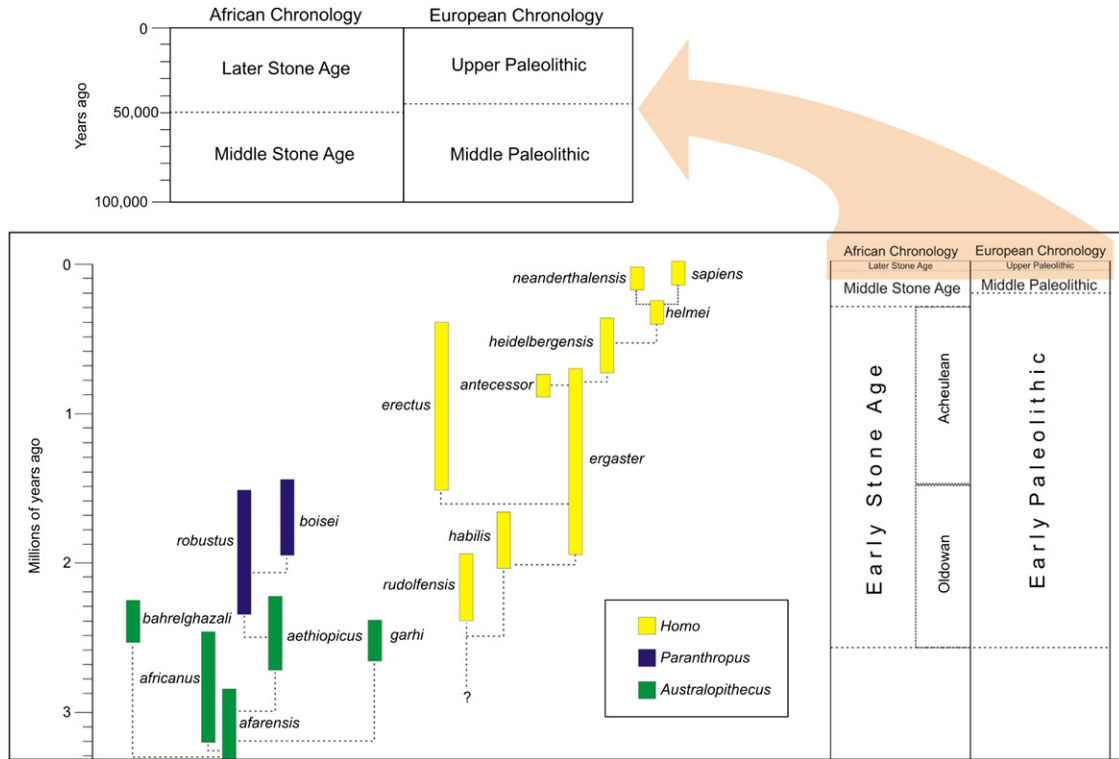


FIGURE 1.1 Timescale of adaptive radiations in humans (left, after Foley, 2002) and major divisions of the Pleistocene (right and above) in African and European archaeology.

played a principal role during hominin evolution, through its direct relationship with visuospatial integration, sensory integration, multimodal processing and social communication. A comparison of distances between noted landmark features of the brain showed changes in the parietal chord and the frontal chord through time. The ratio of these changes is shown in Fig. 1.2. This plot of *Homo erectus*, Neanderthal and anatomically modern human (AMH) brain features show an increase in the frontal/parietal chord ratio from *H. erectus* to *Homo neanderthalensis*, but the AMH specimens show increases in both chords, so the frontal/parietal chord ratio is less than that for *H. neanderthalensis*.

A review of human brain evolution studies by Schoenemann (2006) concluded that,

“Apart from cranial capacity, only suggestive, equivocal clues of possible behavioral patterns are evident in the fossil record of hominin brain evolution, mostly relating to the question of language evolution. Although definitive statements are not currently warranted, we do not presently know the limits of possible inferences about the behavior of fossil hominins from their endocranial remains.”

Schoenemann (2006) suggested that the cognitive demands of tool making might have spurred brain evolution. He noted Reader and Laland’s (2002) study showing that the frequency of tool use in primates is positively

correlated with both absolute and relative brain volume. However, he also noted that research on the importance of stone-tool manufacturing in shaping the evolution of the

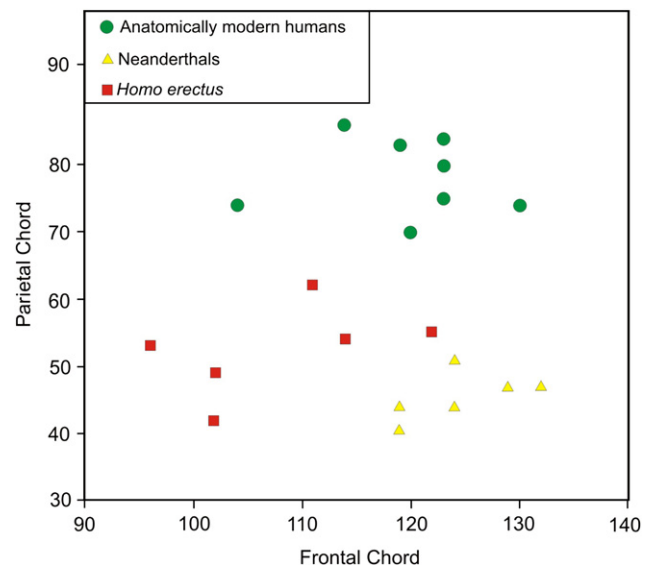


FIGURE 1.2 Bivariate comparisons of frontal chord vs. parietal chord distances, based on cranial measurements from fossil specimens of *Homo erectus*, *Homo neanderthalensis* and *Homo sapiens* (the latter including modern specimens). After Bruner, 2004.

human brain is in its infancy, and that future functional imaging studies are needed to clarify the issue.

Dunbar and Shultz (2007) considered the problem of primate brain evolution from an ecological standpoint, using the social brain hypothesis put forward by Byrne and Whiten (1988) that large brains accompany vertebrates with complex social lives. Viewing brain evolution from a broader ecological perspective, their view is that ecological problem solving (i.e., foraging strategies, offspring rearing and survival) are more effectively solved socially than individually in species exhibiting high degrees of sociality. Again, there is an ecological cost to maintaining a large brain, and this will only be worthwhile (and hence, the large brain trait passed on to succeeding generations) if the benefits outweigh the costs. By comparing the behavioural, ecological and life-history characteristics with the relative brain size of primates, they showed that brain volume does correlate strongly with sociality, and that the neocortex, the part of the brain made up of grey matter and divided into the frontal, parietal, occipital and temporal lobes, plays a critical role in the distinction between humans and other primates.

1.1. THE PROBLEM OF STASIS IN STONE TOOL TECHNOLOGY

The physical evidence of modern and ancestral human's brain size and shape has shed some light on the importance of this great mass of neurons in human evolution. But how do we get at the actual thought processes of our ancestors? These are not etched on the inside of a fossil skullcap. One of the great unsolved mysteries in palaeoanthropology/archaeology is the problem of stasis in stone-tool technology during the Early Pleistocene. After the initial invention of simple stone tools, seemingly little progress was made for an incredibly long time. Clive Gamble's chapter in this volume addresses this problem. Traditionally, archaeologists have attempted to solve such problems through detailed analysis of stone tools. But Gamble's thesis is that this problem cannot be addressed solely on the basis of the record of artefacts left behind by our ancestors. We must try to get into the minds of the early peoples and evaluate the role that their emotions played in driving innovation and creativity. When we focus just on the artefactual record, we are in danger of ignoring the basis of cultural interaction which depends on our sensory responses to both materials and people. Gamble argues that creativity is an embodied act and it is a social act. Early humans may have been enormously creative in their interactions with one another, even if their stone-tool kit failed to change for hundreds of generations. Of course, this places a new burden on archaeologists and palaeoanthropologists, as they attempt to deduce human behaviour and mentality from sources

other than artefacts, but Gamble posits that this is not as impossible as it might seem. He poses the question of how the hominin mind should be modelled, and draws on Gosden's (2010) recent work, and the work of Grove and Coward (2008) and Coward and Gamble (2008), that our cognition is relational rather than rational; thus, hominin creativity does not appear just in symbolic items that were made and manipulated, but rather as a wider consideration of what being en-minded entails. In this context, the Palaeolithic mind is the same as the modern mind, or the mind of many social animals, in that it consists of body (senses and emotions) and things (both animate and inanimate) in reciprocal social partnerships rather than being directed solely by mental instructions sent from the brain. In other words, the brain, acting in concert with the rest of the body, and with tools or other material objects, forms a single unit: the mind in action.

Gamble then addresses the question of how many minds were needed for hominin creativity to evolve. Clearly, when it comes to the success and spread of innovations, the collective consciousness of a large group is more effective than that of the individual in any social species. This is one way in which being part of a larger community has improved the evolutionary fitness of humans throughout their history. We, and our ancestors, are, after all, rather puny, slow-moving, ineffectual organisms as individuals. Virtually all the predators and scavengers with which our ancestors competed on the ancient African savannas were faster, stronger and better equipped with large teeth and sharp claws. However, by working together in groups, and putting their minds together, our ancestors were able to invent survival strategies that led to their eventual climb to the top of the ecological pyramid. As discussed by Shennan (2001), when innovative minds feed off each other, the evolutionary fitness of the group improves.

How does the level of social interaction affect innovation and creativity? The size of an individual's active network apparently grew from about 80 individuals for *Australopithecus* to as many as 150 for our more recent ancestors. Gamble makes the point that larger groups require much higher levels of social interaction than small ones, and that one way humans have coped with this problem is to create hierarchies. Thus, an individual might have just five others in his or her support clique, 15 in his or her sympathy group, 50 in his or her band and 150 in his or her active network. Gamble et al. (2011) argue that this level of social complexity helped drive the expansion of human brain size.

Thus, Gamble argues that complex social behaviour must be acknowledged as a property of all the large-brained hominins that lived after 600,000 years ago, including *Homo heidelbergensis*, Neanderthals, late *H. erectus* and *H. sapiens*. Interestingly, Gamble suggests that what anthropologists call 'anatomically modern humans' might

better be termed ‘behaviourally modern humans’. The archaeology of the last 600,000 years indicates that human-made artefacts (*things*) did not get appreciably more complex until long after social complexity had occurred.

1.2. THE EVOLUTIONARY ECOLOGY OF CREATIVITY

Human beings, modern and ancient, have had the capacity to take existing elements of their environment and modify them to meet their needs. These essentially creative acts are, in some ways, what set us apart from other animals. We take a cobble and turn it into a chopper; we take a set of words and create new sentences from them. In John Hoeffcker’s chapter in this volume, he discusses the creative process in evolutionary and ecological contexts (the two have been tightly interwoven in the history of our ancestral species). Touching on a subject raised by Clive Gamble, Hoeffcker stresses that hierarchical organisation has played a vital role in the development of the human mind. Our brains are wired to collect and then store vast quantities of information. Much of this is useless to us, but it gets stored, regardless of value. But we do make use of the *ability* to acquire and store information in our daily interactions with other people, and this social networking helped drive the evolution of increasing brain size, as discussed by Dunbar (1996).

The gathering and storage of information *per se* would not be worth nearly as much to humanity if we were not able to transform that information, to make it more useful. This is where creativity and innovation come in. Hoeffcker notes that the most recent of the major breakthroughs in the evolution of life, as discussed by Maynard Smith and Szathmáry (1999), has been the development of human societies with language, out of primate societies that essentially lack language. Thus, neural information storage and retrieval, as expressed in human language, can be considered a major evolutionary breakthrough on this planet.

The honeybee is the only other species known to transmit complex hierarchically organised representations necessary for “information-centre” foraging. Their “language” is not verbal, but rather in the form of movements akin to human dance. The bee’s communication is essentially a closed system, lacking the creativity that is found in human languages, with their infinite variety of word combinations.

As early humans spread across Africa and into other continents approximately 2 million years ago, they needed language to convey information to other members of their clan. Where can water be found? What game animals can be found here? Which plants are safe to eat, or effective to use as medicine? Hoeffcker (2012) argues that the driving force behind the formation of the early human societies that dispersed out of Africa was likely the need to exchange

information about such resources. This pattern of cooperative foraging is still seen among male–female pairs in modern human societies. A study by Hill (2002) examined the level of altruistic cooperation during food acquisition by the Ache people of Paraguay, one of the last surviving hunter–gatherer tribes. Her data showed that Ache men and women spend an average of about 10% of all foraging time engaged in altruistic cooperation; when pursuing game animals their cooperative foraging time rises to more than 50%. Hill concluded that cooperative food acquisition and redistribution in hunter–gatherer societies are critical behaviours that probably helped shape universal, evolved, cooperative tendencies.

Another breakthrough in the evolution of human processes is the ability to form a mental template – a means of ordering a series of actions to bring about the desired end. In order to make a hand axe, it is necessary to strike one or more blows in the right place. Not all archaeologists or palaeoanthropologists agree that the fashioning of such simple tools requires a mental template, but Hoeffcker argues that by one million years ago, when biface tools were being made, such a template had to be functioning. The tool-manufacturing process involves three sequential, hierarchically organised steps, requiring a preconceived design. He goes on to argue that the essential difference between the minds of ancestral species and those of modern humans is that the latter exhibit a capacity for potentially unlimited recombination of informational units, hence creativity. By a quarter of a million years ago, humans were producing composite tools and weapons comprising three or four components (e.g., shafts, blades, binding cords and adhesive), with each component made from different raw materials and processed in a different way. Thus, tool making at this time involved the assembling of components in a hierarchically structured, preconceived design. But the designs were flexible, allowing new combinations of elements and materials. Hoeffcker points to this phenomenon as a watershed in the history of human creativity, only to be superseded 200,000 years later by a new level of creativity expressed in the visual arts of the early Upper Palaeolithic in Europe.

1.2.1. Invention, Re-invention and Innovation: Makings of the Oldowan

In her chapter in this volume, Erella Hovers also attacks the problem of identifying creativity in the archaeological record of stone tools. She acknowledges that this problem is shared by all researchers of the Palaeolithic, stating that they have had to abandon attempts to pin down elusive bursts of creativity, those “firsts” that express creative potential, in the records they study. Rather, they have opted to look at the rates of turnover and degrees of variety in artefact forms. Her chapter focuses on the earliest of human

technological innovations, the simple stone tools made by our ancestors 2.6–2.5 million years ago in East Africa, called Oldowan, after Olduvai Gorge, Tanzania, where they were first discovered by the Leakeys in the 1930s. As pointed out by Rogers and Semaw (2009), the Oldowan tools appear to be “something” that emerged out of “nothing”. Thus, they mark the very beginnings of human creativity and innovation, as documented in the archaeological record. Oldowan technology represents the systematic flaking of stone, broadly associated with cutting activities. In ecological terms, stone-tool making was apparently a beneficial adaptation that helped shape the hominin niche for later species of *Australopithecus* and all species of the genus *Homo*. According to Hovers, this relatively simple invention spiralled into widespread innovations within a few hundred thousand years. Hovers addresses two questions in her chapter. First, does Oldowan technology represent a creative event? Are there elements of the Oldowan that may be legitimately considered as the outcome of creative acts? Second, was the spread of the Oldowan after 2.5 Ma due to social learning and cultural transmission, or was it independently reinvented by different groups, time after time, in separate creative acts?

The chapter begins with a discussion on *kinds* of creative thought. Hovers considers two fundamentally different modes, which might (to use modern vernacular phrases) be summarised as creative thinking outside the box, and creative thinking inside the box. The “box” in this case represents the social norms – the familiar thought patterns of a society, be it a small clan of a few individuals, or a larger group. She points out that these two kinds of creativity form the end members of a continuum. In terms of creativity in problem solving, thinking “inside the box” might represent attempts to come up with a solution, based on slight variations on existing methods. Thinking “outside the box” might represent attempts that are stabs in the dark. In human societies, such attempts are likely to be met with the sceptical comment, “But we’ve never done it that way, before.” Armed with this conceptual framework, which I have attempted to summarise in but a few words, Hovers tries to assess whether it can be shown that Oldowan technology represents a real break from the behavioural repertoire that hominins share with apes (i.e., thinking “outside the box” in my summary), and thus an example of exceptional creativity, or whether this technology should be relegated to mundane creativity (thinking inside the box) if it is just an expansion of behaviours known among the apes.

The earliest known stone tools that have been deliberately flaked through percussive blows appear in localities in the Gona region of the Afar depression, northeast Ethiopia, at 2.6 Ma. By 2.4–2.3 Ma, the technology appears at sites in other regions of Ethiopia and Kenya. By 2.1–1.9 Ma, the sites have spread throughout the Rift Valley of East Africa and basins in North and Central Africa, and increased

markedly in number. We cannot tell exactly who made these Oldowan tools, because at least four species of hominins (*Australopithecus garhi*, *Paranthropus boisei*, *Australopithecus aethiopicus* and *Homo* sp.) are known from East Africa between 2.5 and 2 million years ago, and between 2 and 1 million years ago, three more species of *Homo* appeared in the regional fossil record (*H. rudolfensis*, *H. habilis* and *H. erectus*). However, as discussed above, there is good physical evidence from brain case measurements that members of the genus *Homo* demonstrate a significant brain expansion during the period of 2.0–1.0 Ma. This may be linked with a tool making emphasis in their evolution and may have facilitated the ability of *H. erectus* to expand out of Africa by about 2 Ma.

While Oldowan stone-tool flaking technology changed little through this interval, the choice of raw materials from which the tools were made did change. People became more selective, over time. Hovers reviews the literature demonstrating that, in the early Oldowan, raw materials were chosen from local sources, and only transported small distances from their source. After about 2.0 Ma, raw materials were transported greater distances, and apparently were chosen more carefully. For instance, one notable change was a growing tendency to link certain raw materials to the production of certain kinds or shapes of tools. This shows more intentionality and greater knowledge, of both what kinds of stones work best in various tool types and where those kinds of stones can be found.

The validity of Oldowan assemblages older than about 2 Ma has been called into question because local cobbles can be broken into the same shapes as these simple tools through natural causes. Only when exotic-source stones are thus broken can we be more certain that a human agency is involved. Even when accumulations of broken animal bones occur in association with the older assemblages, this combination does not necessarily prove human agency, because the bones may have accumulated naturally along the water courses typically associated with Oldowan sites. Attempting to reconstruct two-million-year-old events is never easy, especially in dry environmental settings where only the rare wet places have much potential to preserve fossils. Stone-tool assemblages that traditionally have been considered to constitute archaeological “sites” in East Africa have thus come under special scrutiny. Hovers notes that the phenomenon of “sites” may be a by-product of the fact that hominins, unlike nonhuman primates, intensively engaged in activities that involved durable raw materials. These durable objects constitute virtually all we know of the material culture of early peoples. Even though it seems certain that these cultures included many perishable items, these have long since decayed, and are archaeologically silent.

Did early Oldowan toolmakers make use of their newly acquired technology to kill animals and process their meat

and bone marrow? Hovers rejects this hypothesis, noting that there is little evidence for percussion, pitting or bone fracturing to access marrow in pre-2.0 Ma sites, and that securely identified cut marks associated with early Oldowan sites mainly come from surface finds, while isolated instances of cut marks from the Middle Awash region that are dated 2.5 Ma are not associated with lithic artefacts, making their interpretation difficult. It seems relatively clear that these early humans had meat in their diet, but how did they obtain it? In fact, they may either have been scavengers or have carved out a niche for themselves that lay somewhere between full-fledged predators and scavengers. Hovers notes the paucity of unambiguous evidence for meat consumption during the first 600,000 years of stone-tool making, and concludes that the makers of early Oldowan tools might just have used them to enhance their supply of plant foods.

Hovers compares and contrasts the tools made by other apes (e.g., chimpanzees) with those made by hominins. She concludes that the flaking of stone with the clear intention of creating a cutting-edged tool is uniquely human. She goes on to specify that in Oldowan stone knapping, familiar elements (stone, gestures of percussion and shapes of accidentally removed flakes with sharp edges) were linked in new ways, leading to useful solutions. Not only were cutting edges achieved, but they were also obtained in large numbers from a given core. Hovers concludes that the invention of Oldowan stone-tool making should be considered an act of exceptional creativity. *Australopithecus* thought outside the box. As Hovers more eloquently puts it, “The first Oldowan stone-tool making involved some breach of a cognitive ‘glass ceiling’.”

Finally, Hovers examines her second main question, whether the subsequent manifestations of Oldowan stone-tool technology represent reinvention or the transmission of knowledge through thousands of generations. While the *mode* of later invention remains obscure, Hovers concludes that the behaviours deduced from the younger Oldowan site assemblages represent expansions of previously known behaviours more than radically novel combinations of such behaviours. At best, these behaviours represent mundane creativity, or “thinking inside the box,” as I put it, earlier.

1.3. EMERGENT PATTERNS OF CREATIVITY AND INNOVATION IN EARLY TECHNOLOGIES

As discussed above, increasing levels of human interaction are likely to have played a significant role in the development of human intellect, leading to increases in creative thought. The chapter by Steven Kuhn in this volume examines emergent patterns of creativity and increasing levels of interaction in early human societies, focussing on

the demographics and network structures of those groups. He does not discount the creative spark of individuals, and its potential to cause great technological leaps forward; however, unfortunately, such individual acts of creation are essentially invisible in the archaeological record. Kuhn is interested in working out the origins of what he calls the “creative explosions” of the Eurasian Upper Palaeolithic and the later Middle Stone Age of Africa, to name just two. He asks, “What factors might affect the rate at which new things (artefacts, processes, etc.) make their appearance in the archaeological record?” He argues that this sort of emergent, aggregate creativity is a product of two broad sets of influences. The first is essentially biological. It is the cognitive capacity of hominins that has allowed them to produce new things and solve problems. But unless these bright ideas are communicated and become widely adopted, they are likely to perish before leaving their mark in the archaeological record. The second set of influences therefore involves the factors that foster the wider diffusion and persistence of such creative ideas.

How and when did major innovative breakthroughs occur? Kuhn warns us not to link such periods with the appearance of new hominin species. As discussed in Kuhn’s chapter, as well as those of Hovers and Zilhão, trends in cultural evolution now appear to have been independent of these important biological transitions (see also Hovers and Kuhn, 2005). For instance, the Neanderthals of late Middle Palaeolithic Europe appear to have produced significant changes in material culture before the arrival of AMH. Kuhn also notes that not all technological advances persisted indefinitely in a given region, citing as an example the impressive cultural developments of the later Middle Stone Age in Southern Africa (ca. 77–58 ka) that were followed by an interval that retained few of these innovations and in fact resembles much older material cultures. In addition to different chronological trajectories for invention (great leaps forward or backward), Kuhn also discusses differences in geographic trajectories of invention, such as the different evolutionary trajectories seen in Lower and Middle Palaeolithic artefacts between East Asia and Western Europe.

Not all technological novelty is due to the same forces. Kuhn makes the distinction between random copying errors, a kind of genetic mutation in material culture, and purposeful, directed experimentation that brings about an innovation. The latter is a genuine form of creativity. Ultimately, it does not matter which kind of innovation is involved. If the result is sufficiently useful to a group of individuals, so much so that other groups take notice and want to copy it, then the invention has a good chance of persisting beyond the limited space and time of its creation. Transmission of innovative ideas takes place most easily in large groups of people, just as genetic mutations are more easily passed on to successive generations in large populations of a species. Kuhn points to the papers by Shennan

(2001) and Powell et al. (2009) that stress the link between demographic changes (i.e., times of substantial increases in human population in given regions) and times of major cultural or technological innovation. Conversely, times of population declines have been correlated with losses of elements of material culture in isolated populations. One of the overriding themes of Kuhn's chapter is, therefore, that progress in the invention of material culture has not been unidirectional. Rather, such advances can be either halted for long periods of time or even reversed during periods of population decline. He cites the earliest occupation of the southern fringes of Europe by people in the Lower Palaeolithic as an example. They left precious little evidence of technological innovation, but Kuhn argues that the uncertainties of living at the extreme edges of their species range could have made for small and unstable populations in which accumulated cultural knowledge could easily be lost by chance events. Thus, population stability may place as important a role in the pace of innovation as population size.

Networking is something at which modern humans are relatively good, and there is little doubt that some form of network building has been going on in humankind for hundreds of thousands of years. Of course, most human networks involve those closest to us, but long-distance networks can also be important in the transmission of new ideas, a fact emphasised by Kuhn as a means of buffering the negative influence of the dying out of small, local populations. Kuhn points out that hunter-gatherers maintain social networks with people outside their immediate clans, whether or not these outsiders are kin. Trade networks have a role to play here. The human desire to acquire exotic goods from distant regions has been demonstrated in the archaeological record, at least as far back as the Upper Palaeolithic (Barton et al., 1994). Kuhn identifies long-distance transport of highly prized workable stone, such as obsidian, in the late Middle Stone Age of Africa (roughly 75,000–50,000 yr ago).

Demographics play an increasingly important role in human cognition in the Upper Palaeolithic, according to Kuhn, because the level of social interactions rise, facilitating social learning. According to social learning theory (Bandura, 1977), humans learn from their environment. As long as humans were living in relatively small, isolated communities, social learning was likewise limited. But when populations rose, as they did at times in Upper Palaeolithic Europe, for instance, then the level of social interaction also rose, and with it came enhanced social learning. In this setting, small-scale innovations can accumulate and spread rapidly in a society.

Finally, Kuhn makes an interesting observation on the role of hardship in stimulating innovation. Again, linking this phenomenon with demographics, he observes that if environmental stress (e.g., the onset of a cold interval in Late Pleistocene Europe) is too great, rather than

stimulating innovation, its main impact is to lower population size through death or migration. Smaller populations have fewer social interactions, which Kuhn considers an important driver in innovation and creativity.

1.3.1. Personal Ornaments and Symbolism Among the Neanderthals

Having considered the origins of creativity and innovation among the earlier species of hominins, we now shift our gaze to one of the most recent species, *H. neanderthalensis*, or Neanderthal man. This volume includes two chapters devoted to various aspects of Neanderthal creativity. The first of these is by João Zilhão. He takes the old paradigms about Neanderthal inventiveness to task. The discovery of the fossil skullcap and other bones of a non-AMH in the Neander valley of Germany in 1856 represents a watershed in palaeoanthropology. Victorian Europeans were not ready to consider that an extinct, ancient human might have been (a) closely related to modern humans and (b) our intellectual equals. One of the first artist's reconstructions of Neanderthal man, from 1909, is quite telling (Fig. 1.3). Here we see, literally, an ape-man, covered with fur, crouched like a gorilla, with the look of a dangerous wild animal in its eyes. Both the general public and, to a large extent, palaeoanthropologists of previous generations always emphasised the "other-ness" of Neanderthals. Until the discovery of a Neanderthal hyoid bone in Kebara Cave, Israel (Bar-Yosef et al., 1992), most palaeoanthropology textbooks stated that Neanderthals had little or no power of speech, much less anything resembling modern human language. Artefactual evidence contradicting this ape-man paradigm was either ignored by most researchers, or ascribed to modern humans, in spite of stratigraphic or dating evidence to the contrary. This line of thinking was decidedly circular: "Neanderthals were not intelligent or creative enough to have made this set of artefacts, therefore they *must* have been made by modern humans." Zilhão systematically challenges the old paradigms, taking a fresh look at the archaeological evidence.

In Zilhão's chapter, he identifies two statements concerning indicators of "behavioural modernity" in the African archaeological record whose validity is widely accepted by palaeoanthropologists. First is a definitive statement by Henshilwood and Marean (2003): "Artefacts or features carrying a clear, exosomatic symbolic message, such as personal ornaments, depictions, or even a tool clearly made to identify its maker." Second is a different take on modernity by Brown et al. (2009): "Complex use of technology, namely the controlled use of fire as an engineering tool to alter raw-materials; for example, heat pre-treating poor-quality siliceous rocks to enhance their flaking properties". Zilhão argues that, if these statements may be used

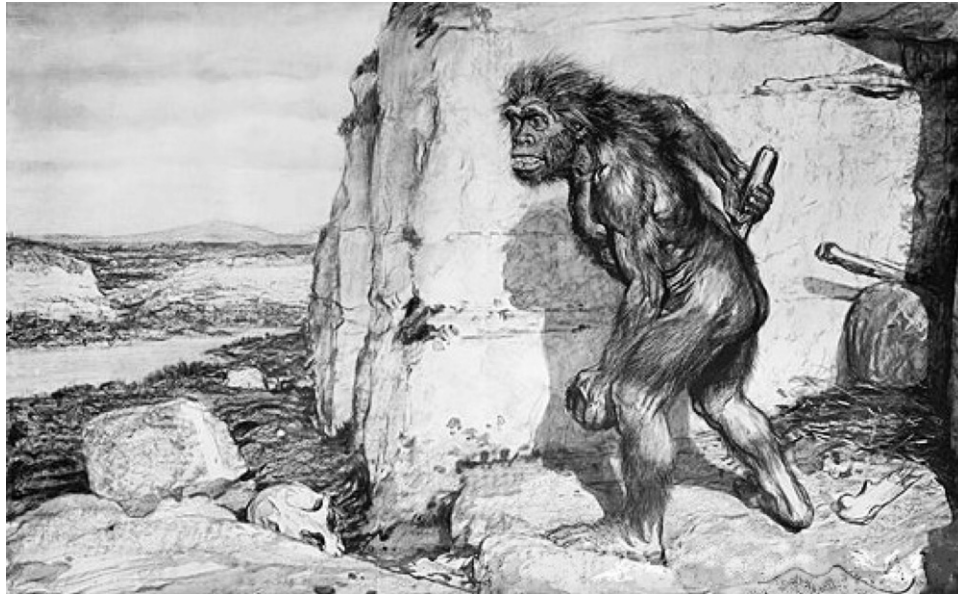


FIGURE 1.3 Artist's reconstruction of the Neanderthal 'Man of Chapelle-Aux-Saints' by Mr. Kupka (scientifically advised by Marcellin Boule) for the Illustrated London News, 27 February, 1909.

to define modernity, then any clear-cut evidence that Neanderthals fit these descriptions *must* be taken as evidence of their behavioural modernity.

The first instance of archaeologists and palaeo-anthropologists ignoring or discounting evidence of the use of symbolism amongst Neanderthals comes from the French rockshelter of La Ferrassie, in the Dordogne (Peyrony, 1934; Defleur, 1993). Here, the remains of seven Neanderthals were found in a single level of a deeply stratified deposit. Based on cultural indicators linked with other sites in France, these people were buried between 60,000 and 75,000 years ago. These facts are undisputed, but what was overlooked for more than 70 years were two significant features of these burials: a bone fragment decorated with four sets of parallel incisions that lay next to an adult male, and a limestone slab decorated with cup holes that was buried in a deep pit with a child.

Zilhão also cites a prime example of the use of complex technology by Neanderthals, from the open-air site of Königsau, eastern Germany (Mania, 2002). This site yielded fragments of birch bark pitch, one of which bore a human fingerprint as well as impressions of a flint blade and of wood-cell structures, indicating use as an adhesive material to fix a wooden haft to a stone knife. Radiocarbon dating yielded an age greater than 50,000 yr BP, and chemical analysis showed that the pitch had been produced through a lengthy smouldering process requiring a strict protocol: oxygen was excluded and the temperature had to be 340–400 °C to get this product. At the Italian site of Campitello, birch bark pitch remains date to >120,000 yr BP, making this pitch the first known artificial raw material in the history of humankind. Zilhão states that the sophistication of the fire

technology employed in the production of this adhesive pitch remained unsurpassed until the invention of Neolithic pottery kilns. Zilhão argues that these and other examples should have led palaeoanthropologists to the conclusion that Neanderthals were more behaviourally advanced than AMH, but the dominant theme in the discussion remained the idea that Neanderthals went extinct in the Late Pleistocene, so they must have somehow been inferior to the AMH with which they cohabited Europe during the last glacial interval. The “out of Africa” and “human revolution” concepts drove palaeoanthropology, and the attention of researchers, away from the evidence discussed above.

One method of discounting Neanderthal use of symbolism is to argue that this was a very late development amongst Neanderthals, based on their imitation of behaviours exhibited by the AMH co-occupying Europe in the Late Pleistocene. A second method used to explain away Neanderthal use of symbolism is the two-pronged argument that (a) the sites where the artefacts might suggest Neanderthal use of symbolism are actually very rare and (b) in these rare cases, overlying AMH artefacts have been reworked to lower (Neanderthal) occupation layers.

Zilhão argues that the first method of explaining away Neanderthal use of symbolism (imitation of objects and behaviours of AMH cohabiting Europe) can now be firmly put to rest on the basis of improved chronostratigraphic control of European Upper Palaeolithic sites, coupled with improved radiometric dating of sites. These refinements show that the emergence of the Châtelperronian (Neanderthal) culture predates the earliest Aurignacian (AMH) culture as well as the earliest skeletal evidence for AMH throughout Europe by many thousands of years. He attacks

the second argument (intrusion of AMH symbolic artefacts into Neanderthal layers at multioccupation sites) by positing that there are many sites where symbolic objects are clearly associated with Neanderthal occupation; so, even if attempts to discredit single sites are successful, these do not negate the whole body of evidence. He also cites Caron et al. (2011), in a detailed argument refuting attempts to relegate Neanderthal symbolic artefacts at the Grotte du Renne site in France as intrusive elements from overlying AMH layers, stating that this is completely inconsistent with their vertical distribution across the site's stratigraphic sequence. He cites supporting evidence from other Châtelperronian sites in Europe, including Quinçay rock shelter in France, the Ilsehöhle rock shelter in Germany, the Trou Magrite (Pont-à-Lesse) site in Belgium, Bacho Kiro cave (Dryanovo) in Bulgaria, Klisoura 1 cave in Prosymna, Greece and Fumane rockshelter in Molina, Italy. In each case, artefacts with clearly symbolic significance have been found in Châtelperronian contexts, and each assemblage has been dated from 41,000 to 45,000 calendar years ago.

Zilhão et al., 2010 have also described Mousterian-level perforated shells from two Spanish caves (Cueva de los Aviones and Cueva Antón). These assemblages date back to 50,000 yr BP. One oyster shell had been used as a container for the storage or preparation of a complex cosmetic pigment most likely used as body paint. There were lumps of iron pigments of different mineral species (hematite, goethite and siderite), and especially yellow natrojarosite, whose only known use is in cosmetics. They also found an unmodified pointed bone bearing pigment residues on the broken tip, suggesting its use in the preparation or application of colourants. Zilhão argues in this volume that these artefacts, plus similar finds of pigments from Pech de l'Azé, Carsac-Aillac, France and the middle Palaeolithic in the Qazfeh Cave, Israel, present clear evidence for the use of body paint by Neanderthals.

In recent years, the evidence discussed above has been more widely accepted by both the general public and by the scientific community. Zilhão suggests that this new acceptance corresponds to the publishing of the first results of the Neanderthal genome project, published at about the same time (Green et al., 2010). The ancient DNA evidence indicates that modern humans share some DNA with Neanderthals, indicating that there must have been some interbreeding between the two groups in the Late Pleistocene. This, in turn, removed the need for considering AMH and Neanderthals as completely separate, competing species. If the "other-ness" of Neanderthals, the prevailing paradigm for 150 years of palaeoanthropology, could be at least weakened, if not nullified by the DNA evidence, then this helped eliminate the barriers to acknowledging that Neanderthals had fully human cognition, as evidenced by artefacts indicating a fully symbolic material culture. Not all archaeologists or palaeoanthropologists are convinced, of course.

Old paradigms die hard, in archaeology and elsewhere. The earliest impressions of Neanderthals were that they were hairy ape-men. As Zilhão so aptly says in his chapter, "You never get a second chance to make a first impression."

1.3.2. Climate, Creativity and Competition: Evaluating the Neanderthal "Glass Ceiling"

Zilhão's chapter provides evidence that, at least in their last few millennia of existence, Neanderthals had fully human cognition and behaviour. In the second chapter concerning Neanderthals, William Davies approaches Neanderthal archaeology from a different viewpoint. He asks how they changed and developed over the course of their long (200,000-year) existence, how they innovated and interacted and how climate and competition affected them. Davies' chapter in this volume thus takes a longer view of *H. neanderthalensis*. Using an environmental approach, Davies places Neanderthal innovations in the context of environmental pressures. He proposes that these innovations were fairly constantly generated in the Palaeolithic, but selection pressures were more severe against them in times of environmental adversity. Thus, climate might have exerted little pressure on the *rate* of innovation, but rather more on the fate of those innovations.

Davies constructs a theoretical framework by which to judge Neanderthal innovation throughout the course of their history. He considers change at different material culture scales (from small to large), and in terms of its structure and social organisation. Small-scale changes should have the highest turnover (perhaps days or weeks) and be restricted to the intrasite scale, while large-scale change should occur over longer periods, ranging from decadal to centennial spread across wide areas.

Demography (e.g., population density and social structure) needs to be considered in the development and transmission of novel traits. Larger populations may increase the number and rate of invention, as discussed in relation to Kuhn's chapter, but Davies argues that social structure and connectedness are a better explanation for transmission of new ideas, especially in mobile populations. Mobility is another important factor. The effect of different scales of mobility needs to be recognised in the generation and transmission of novel traits. More sedentary populations will transmit (or not) their ideas in different ways, and perhaps at different rates, than more mobile populations. Innovations may spread through face-to-face contact or they can spread greater distances through social networks. Davies laments the low number of reliable chronologies for Neanderthal sites, especially for sites beyond the range of radiocarbon dating (i.e., 50,000 yr BP). Without accurate dates for sites and artefacts, the *pace* of innovation and transmission of ideas cannot be determined.

Davies defines various categories of Neanderthal innovations, so that each can be independently assessed. These include burial of the dead, the use of different parts of sites for different functions, blade and bladelet technology, the use of bone, antler and ivory artefacts and tools, the possible use and manufacture of “symbolic” artefacts, e.g., beads, and efficient, specialised hunting strategies. The evidence for Neanderthal burial of their dead mostly comes from southwest France, the Ardennes, the Crimea, the Levant and the Zagros Mountains. The majority of burials are dated between 70,000 and 40,000 BP. Other methods of disposal of corpses were also practiced, and Davies concludes that there is no clear-cut pattern of transmission of burial practice innovation, either spatially or temporally. There is no also clear-cut pattern of Neanderthal use of different parts of their habitation sites for different purposes. Davies concludes that this apparent lack of differentiation of living spaces means that there were no *specific* locations for transmission of novel ideas and techniques in Neanderthal sites, though perhaps such transmission might be concentrated in the areas of greatest activity. Neanderthal blade production demonstrates flexible, fluid knapping strategies, and their production of “nanopoint” bladelets less than 1 cm long demonstrates Neanderthal innovation, dexterity and technical precision. Davies argues that the use of ivory, antler, bone and shell artefacts was both spatially limited (mostly to northern France) and temporally limited (between about 45,000 and 36,500 BP). Further, he argues that the use of beads and pendants is not ubiquitous in Neanderthal sites. Finally, concerning specialised hunting strategies, Davies weighs the evidence and concludes that, while there is evidence of butchery of prime individuals, there is no evidence of a trend in Neanderthal selection of prime animals over less fit individuals. The existing examples are both spatially and temporally discontinuous. Thus, it is difficult to gauge the extent and scale of Neanderthal innovation in hunting specialisation.

Davies argues that this lack of evidence for the spread of innovation could just as easily be applied to *H. sapiens* populations prior to ca. 50,000 BP. Only as population densities rose (between 50,000 and 35,000 BP) did AMH begin to consistently transmit innovations. Prior to 50,000 yr BP, populations of both species were too patchy in most regions to facilitate the transmission of new ideas. As the range of Neanderthals contracted after 50,000 BP into parts of Europe, their population densities may have risen, facilitating the spread of ideas in the last remaining groups. Davies notes that after 50,000 BP, both Neanderthals and AMH show increasing evidence for symbolic activity, e.g., bead production. His chapter argues that such increases in symbolic activity can be attributed to increased social interaction, but in the case of the Neanderthals, this was perhaps linked with increasing stress on social systems. However, Davies warns that while it might seem that the

intensity of Neanderthal innovation and inventiveness increased after about 50,000–45,000 years ago, we cannot be sure at present if this apparent shift is an artefact of our dating, or a behavioural reality. The limitations of the radiocarbon method may be imposing a false time barrier on our comprehension of Neanderthal behaviour, because it is much more difficult to date artefact assemblages that are beyond this 50,000-year boundary.

On the question of Neanderthal imitation of behaviours exhibited by the AMH co-occupying Europe in the Late Pleistocene, Davies urges caution. He says that we cannot really say if Neanderthals and *H. sapiens* influenced each other’s innovations, or whether they developed independently, and that it is difficult in many situations to distinguish independent (re)invention of characteristics from inter-Neanderthal acculturation.

Why did the spread of novel ideas, at least before 50,000 yr BP, take such a long time in Neanderthal societies? Davies describes the Neanderthal social world as comprising many small-scale closed networks, with limited exchange of information and ideas. This is clearly not the ideal substrate for either the transmission or the long-term persistence of new ideas and techniques. This social structure seems to be the best explanation available for the pattern of change seen in Neanderthal assemblages.

1.3.3. North African Origins of Symbolically Mediated Behaviour and the Aterian

In the final chapter of this book, Nick Barton and Francesco d’Errico focus their attention on the nature and timing of a few key innovations in the cultural record of North Africa during the Middle Palaeolithic/Middle Stone Age (MP/MSA). In developing the history of human innovation and creativity, North Africa was traditionally considered by archaeologists to have been “cul de sac”, overshadowed by the more prolific records of East and sub-Saharan Africa. However, more recent attention has focused on the early use of symbolism in the Aterian industry of the MP/MSA. This industry has been found at sites spanning much of the Sahara, from the Atlantic coast of Morocco to Egypt and the Sudan. The bulk of the evidence indicates that the skeletons found at some Aterian sites represent AMH remains. The sites date back as far as 80,000 yr BP. The most widely accepted definition of the Aterian is that of Tixier (1967), based on stone tools described from Oued Djebbana, Algeria. He described the Aterian as a Levallois industry with a laminar or blade-like debitage showing a high proportion of faceted butts. In this method of stone-tool production, a striking platform is formed at one end of a core, and then the edges are trimmed by flaking off pieces around the perimeter. This creates a domed shape on the side of the core, known as

a tortoise core, as the tool at this stage resembles a tortoise shell. When the platform is struck, a flake is driven off from the core that has a distinctive plano-convex profile. All of its edges are sharpened, due to the earlier edge trimming. As described by Barton and d’Errico, the Aterian toolkit includes side-scrapers and points, with a predominance of end-scrapers. Another important element are pedunculate tools that have a tang at their proximal end (Fig. 1.1). There is often bifacial thinning of the tanged ends, facilitating their mounting on shafts or handles. One of the most striking features of Aterian lithic technology is the co-occurrence of these thinned pedunculate tools and bifacially flaked, foliate points. The points appear to have been made as projectile points, but some of them are so small that they seem more likely to have been used on arrows, rather than on spears.

Recent excitement concerning the Aterian in the archaeological community has come about because of newly revised age estimates for this industry. Barton and d’Errico discuss optically stimulated luminescence (OSL) ages; in addition to uranium-series dates and thermoluminescence (TL) ages from sites in Morocco, they place this technology back to MIS 6, with TL dates from 145,000–171,000 yr BP. Further west on the Atlantic coast in the Témara district of Rabat, the earliest Aterian industry at one site has been OSL dated to MIS 5e, ca. 114,000–105,000 yr BP (Barton et al., 2009), and at a nearby site the layers containing Aterian artefacts date from 100,000 to 121,000 yr BP (Schwenninger et al., 2010). The Aterian has mostly been dated from 60,000 to 80,000 further east on the North African coast in Libya and Tunisia, although sites in Egypt have yielded uranium-series ages of $126,000 \pm 4000$ yr BP and an electron spin resonance (ESR) minimum age of $96,240 \pm 2500$ yr BP; so a clear geographic pattern for the spread of this lithic industry has not yet appeared.

Barton and d’Errico also report on the first finds of red pigments in Aterian assemblages in Morocco, dated 111,000–105,000 yr BP, and on the use of red ochre at several Moroccan cave sites, that date from 83,000 to 82,000 yr BP. Personal adornment is a key symbolic behaviour, and this has been found in Aterian sites in the form of shell beads. Barton and d’Errico discuss perforated marine snail shells of the taxa *Nassarius gibbosulus*, *Nassarius circumcinctus* and *Columbella*. These finds date from 83,000 to about 60,000 yr BP in Moroccan cave sites. Interestingly, none of the shell bead artefacts dates from the oldest Aterian occupation layers at these sites.

Assessing the Aterian technocomplex in light of the changing environments of North Africa from MIS 6-3, Barton and d’Errico note that it may have persisted for more than 70,000 years, successfully enduring major environmental changes, and extending across a territory of 1,000,000 km². Most of the recently dated Aterian sites are associated with the interval of variable climate in the earlier phases of MIS 5 (MIS 5e-c), and the beginning of MIS 5a,

which is characterised by a gradual decrease of temperatures and precipitation. The Aterian may have persisted through the cool, dry conditions of MIS 4, until the onset of MIS 3. There were few changes in the Aterian toolkit throughout its 70,000-year history. Barton and d’Errico conclude that the features that made the Aterian so successful can at the same time also be perceived as symptomatic of its inherent limitations. Contemporaneous and younger cultures in Europe, the Middle East and southern Africa provide better examples of the kind of rapid cultural changes we associate with modernity. These other regions apparently experienced environmental changes such as sea-level fluctuations that led to human habitat expansions and contractions, and there were intervals of population growth, during which the pace of technological change is more likely to increase (see the discussion of this in the section on Kuhn’s chapter, above). However, sea-level changes had little effect on the coasts of North Africa, and the initial phases of each interglacial opened pathways through the Sahara (expansion of lakes and rivers), which paradoxically reduced the isolation of this region.

1.4. CONCLUDING REMARKS

The history of human creativity and innovation is very challenging to reconstruct. The authors contributing to this volume have, themselves, demonstrated considerable creativity in their manifold approaches to this thorny topic. It is often difficult, if not impossible, to determine *who* made a given artefact (i.e., which species of human) and exactly *when* it was made. The questions of *how* and *where* are often somewhat easier to address, but “*why*” is often the most difficult of all these questions. The authors have tried their best to “get into” the minds of ancient peoples. While the results of these endeavours are necessarily speculative, they may serve to advance the sciences of palaeo-anthropology and archaeology, not least by challenging old assumptions and breaking old paradigms. A recurring theme in this volume is that increased levels of human interaction appear to be a powerful driver of creative thinking, as expressed in technological innovation. It is a great frustration that all we have to go on when we set out to interpret an ancient culture is a set of stone tools and a few other durable artefacts. Not only do we know little or nothing about the perishable elements of these cultures (i.e., clothing and other textiles, nets, rope, etc.), but there are other vital aspects of their cultures we will never know about, unless a means of time travel is invented. What songs did they sing? What stories did they tell? How were children taught what they needed to know? But this is not to disparage the efforts to understand the origins of human creativity and innovation documented in this volume and elsewhere. These writings represent real progress in the difficult voyage of discovery.

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